

Supplementary Material: Exact Structural Abstraction and Tractability Limits

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The archived artifact is available at <https://doi.org/10.5281/zenodo.19457896>.

1 Full Lean Handle Ledger

This supplement provides the complete Lean handle ledger cited by the manuscript. It includes every handle identifier, declaration name, and source module path. Handle IDs are sparse because uncited formalization lemmas are omitted from the manuscript ledger; the full artifact is available at the Zenodo DOI above. The ledger references two formalization trees, `Paper4dFrontier/` and `paper4/DecisionQuotient/`, both included in the archived artifact.

ID	Lean Handle / Source	ID	Lean Handle / Source
FR7	<code>exists_decisionProblem_realizing_labeling</code> <code>Paper4dFrontier/Realizability.lean</code>	FR8	<code>realizingProblem_decisionEquiv_iff</code> <code>Paper4dFrontier/Realizability.lean</code>
FR13	<code>isOptimal_positiveAffineTransform_iff</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>	FR14	<code>opt_eq_positiveAffineTransform</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>
FR15	<code>isSufficient_positiveAffineTransform_iff</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>	FR16	<code>isRelevant_positiveAffineTransform_iff</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>
FR17	<code>decisionEquiv_relabelActions_iff</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>	FR18	<code>decisionEquiv_relabelStates_iff</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>
FR19	<code>isSufficient_relabelActions_iff</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>	FR20	<code>isSufficient_relabelStates_iff</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>
FR21	<code>allProblems_relabelInvariant</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>	FR22	<code>allProblems_kernelUniversal</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>
FR23	<code>relabelInvariant_not_enough</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>	FR24	<code>optRangeCard_realizingIdentity</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>
FR30	<code>isSufficient_iff_of_decisionEquiv_iff</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>	FR31	<code>isRelevant_iff_of_decisionEquiv_iff</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>
FR32	<code>isIrrelevant_iff_of_decisionEquiv_iff</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>	FR33	<code>isMinimalSufficient_iff_of_decisionEquiv_iff</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>
FR34	<code>sufficientSets_eq_of_decisionEquiv_iff</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>	FR35	<code>relevantSet_eq_of_decisionEquiv_iff</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>
FR37	<code>quotientCard_eq_of_decisionEquiv_iff</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>	FR38	<code>quotientCard_realizingIdentity</code> <code>Paper4dFrontier/FamilyAxioms.lean</code>
FR39	<code>realizingProblemQuotientEquivLabelRange_apply_quotientMap</code> <code>Paper4dFrontier/Realizability.lean</code>	FR40	<code>realizingProblem_quotientCard_eq_labelRangeCard</code> <code>Paper4dFrontier/Realizability.lean</code>

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ID	Lean Handle / Source	ID	Lean Handle / Source
FR41	certificationStatistic_eq_of_decisionEquiv_iff Paper4dFrontier/FamilyAxioms.lean	FR42	sufficientSetCount_eq_of_decisionEquiv_iff Paper4dFrontier/FamilyAxioms.lean
FR43	minimalSufficientSetCount_eq_of_decisionEquiv_iff Paper4dFrontier/FamilyAxioms.lean	FR44	relevantCoordCount_eq_of_decisionEquiv_iff Paper4dFrontier/FamilyAxioms.lean
FR45	setoidRealizingProblem_decisionEquiv_iff Paper4dFrontier/Realizability.lean	FR46	setoidRealizingProblemQuotientEquivSetoidQuotient_apply_quotientMap Paper4dFrontier/Realizability.lean
FR47	exists_decisionProblem_realizing_setoid Paper4dFrontier/Realizability.lean	FR48	isSufficient_iff_agreementRel_le_decisionEquiv Paper4dFrontier/FamilyAxioms.lean
FR49	isIrrelevant_iff_sufficient_erase Paper4dFrontier/FamilyAxioms.lean	FR50	isRelevant_iff_not_sufficient_erase Paper4dFrontier/FamilyAxioms.lean
FR51	quotientEquiv_of_decisionEquiv_iff_apply_quotientMap Paper4dFrontier/FamilyAxioms.lean	FR52	empty_sufficient_of_constant_opt Paper4dFrontier/ClosureLaws.lean
FR53	irrelevant_of_constant_opt Paper4dFrontier/ClosureLaws.lean	FR54	decisionEquiv_duplicateAction_iff Paper4dFrontier/ClosureLaws.lean
FR55	isSufficient_duplicateAction_iff Paper4dFrontier/ClosureLaws.lean	FR56	isRelevant_duplicateAction_iff Paper4dFrontier/ClosureLaws.lean
FR57	decisionEquiv_duplicateState_iff Paper4dFrontier/ClosureLaws.lean	FR58	isSufficient_duplicateState_iff Paper4dFrontier/ClosureLaws.lean
FR59	isRelevant_duplicateState_iff Paper4dFrontier/ClosureLaws.lean	FR60	duplicateStateQuotientEquivOriginal_apply_quotientMap Paper4dFrontier/ClosureLaws.lean
FR66	booleanCube_card Paper4dFrontier/EnumerationBounds.lean	FR67	exists_booleanCube_larger_than_monomial Paper4dFrontier/EnumerationBounds.lean
FR68	decisionEquiv_addDuplicateState_iff Paper4dFrontier/ClosureLaws.lean	FR69	isSufficient_addDuplicateState_iff Paper4dFrontier/ClosureLaws.lean
FR70	isRelevant_addDuplicateState_iff Paper4dFrontier/ClosureLaws.lean	FR71	addDuplicateStateQuotientEquivOriginal_apply_quotientMap Paper4dFrontier/ClosureLaws.lean
FR72	some_mem_opt_addDuplicateAction_iff Paper4dFrontier/ClosureLaws.lean	FR73	none_mem_opt_addDuplicateAction_iff Paper4dFrontier/ClosureLaws.lean
FR83	isSufficient_noiseExtended_iff Paper4dFrontier/ DimensionalNoiseExtension.lean	FR84	isRelevant_noiseExtended_iff Paper4dFrontier/ DimensionalNoiseExtension.lean
FR85	lastCoord_irrelevant_noiseExtended Paper4dFrontier/ DimensionalNoiseExtension.lean	FR118	pairCrossDifference_eq_binaryCrossDifference_of_lt Paper4dFrontier/ BinaryPairwiseDichotomy.lean
FR119	pairwise_zero_crossDifference_unaryDecomposition Paper4dFrontier/ BinaryPairwiseDichotomy.lean	FR120	binary_pairwise_symmetry_dichotomy Paper4dFrontier/ BinaryPairwiseDichotomy.lean
FR121	actionGapCrossDifference_eq_binaryCrossDifference_of_lt Paper4dFrontier/ DecisionRelevantPairwiseDichotomy.lean	FR122	decisionRelevant_zero_actionGap_implies_unaryReduction Paper4dFrontier/ DecisionRelevantPairwiseDichotomy.lean

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ID	Lean Handle / Source	ID	Lean Handle / Source
FR123	binary_pairwise_symmetry_decision_relevant_dichotomy Paper4dFrontier/ DecisionRelevantPairwiseDichotomy.lean	FR124	block6_genuine_interaction_dichotomy_obstruction Paper4dFrontier/Block6Obstruction.lean
FR125	decisionRelevantInteractionGraph_addActionOffset Paper4dFrontier/ DecisionRelevantPairwiseDichotomy.lean	FR126	action_offset_can_force_constant_optimizer Paper4dFrontier/Block6Obstruction.lean
FR127	block6_action_offset_obstruction Paper4dFrontier/Block6Obstruction.lean	FR128	offsetNormalizedDecisionRelevantInteractionGraph_wellDefined Paper4dFrontier/ DecisionRelevantPairwiseDichotomy.lean
FR129	block6_offset_normalized_obstruction Paper4dFrontier/Block6Obstruction.lean	FR130	neverOptimalGhost_decisionRelevantGraph_eq_top Paper4dFrontier/Block6Obstruction.lean
FR131	neverOptimalGhost_supportedGraph_eq_bot Paper4dFrontier/Block6Obstruction.lean	FR132	support_filtering_removes_known_block6_obstructions Paper4dFrontier/Block6Obstruction.lean
FR133	block6_ghost_action_obstruction Paper4dFrontier/Block6Obstruction.lean	FR134	marginMasking_supportedGraph_eq_top Paper4dFrontier/Block6Obstruction.lean
FR135	marginMasking_zero_sufficient Paper4dFrontier/Block6Obstruction.lean	FR136	block6_optimizer_supported_obstruction Paper4dFrontier/Block6Obstruction.lean
FR137	MarginBounded Paper4dFrontier/ DecisionRelevantPairwiseDichotomy.lean	FR138	dominantPair_marginBounded Paper4dFrontier/Block6Obstruction.lean
FR139	dominantPair_supportedGraph_eq_top Paper4dFrontier/Block6Obstruction.lean	FR140	block6_margin_bounded_obstruction Paper4dFrontier/Block6Obstruction.lean
FR145	not_collapseLandscapeInfinity_of_oracle_predicate Paper4dFrontier/MetaCharacterization.lean	FR176	DecisionQuotient.DecisionProblem.quotient_is_coarsest paper4/DecisionQuotient/Quotient.lean
FR177	DecisionQuotient.DecisionProblem.quotient_has_unique_factorization paper4/DecisionQuotient/Quotient.lean	FR178	DecisionQuotient.DecisionProblem.srank_eq_relevant_card paper4/DecisionQuotient/Tractability/StructuralRank.lean
FR179	DecisionQuotient.quotientEntropy_le_srank_binary paper4/DecisionQuotient/Information.lean	FR180	DecisionQuotient.Statistics.fisherMatrix_rank_eq_srank paper4/DecisionQuotient/Statistics/FisherInformation.lean
FR181	DecisionQuotient.Information.compression_below_srank_fails paper4/DecisionQuotient/Information/RDSrank.lean	FR182	DecisionQuotient.Information.srank_bits_sufficient paper4/DecisionQuotient/Information/RDSrank.lean
FR183	DecisionQuotient.Physics.single_future_zero_cost paper4/DecisionQuotient/Physics/WassersteinIntegrity.lean	FR184	DecisionQuotient.Physics.transportCost_pos_of_offDiag paper4/DecisionQuotient/Physics/WassersteinIntegrity.lean
FR185	no_closureInvariant_predicate_of_orbit_gap Paper4dFrontier/ ObstructionPredicateCandidates.lean	FR186	no_admissibleNormalizationPredicate_decides_dominantPair Paper4dFrontier/ ObstructionPredicateCandidates.lean
FR187	no_admissibleNormalizationPredicate_decides_marginBounded Paper4dFrontier/ ObstructionPredicateCandidates.lean	FR188	no_admissibleNormalizationPredicate_decides_ghostActionTwoPairCrossOne Paper4dFrontier/ ObstructionPredicateCandidates.lean

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ID	Lean Handle / Source	ID	Lean Handle / Source
FR189	no_admissibleNormalizationPredicate_decides_offsetActionZeroPairCrossOne Paper4dFrontier/ ObstructionPredicateCandidates.lean	FR191	ClosureSoundPackage Paper4dFrontier/ ObstructionPredicateCandidates.lean
FR192	ReasonableGuardrailPackage Paper4dFrontier/ ObstructionPredicateCandidates.lean	FR193	no_closureSoundPackage_predicate_decides_four_obstruction_families Paper4dFrontier/ ObstructionPredicateCandidates.lean
FR197	classifier_agrees_on_closureEquivalent_of_correctOnDomain Paper4dFrontier/ AdmissibleCharacterization.lean	FR198	no_correctOnDomain_classifier_of_orbit_gap Paper4dFrontier/ AdmissibleCharacterization.lean
FR199	correct_classifier_inherits_closureLawInvariant Paper4dFrontier/ AdmissibleCharacterization.lean	FR200	admissibleNormalizationPredicate_has_explicit_inhabitants Paper4dFrontier/ AdmissibleCharacterization.lean
FR201	closureLawInvariant_of_iff_of_closureEquivalent Paper4dFrontier/ AdmissibleCharacterization.lean	FR202	exists_orbit_gap_of_not_closureLawInvariant Paper4dFrontier/ AdmissibleCharacterization.lean
FR203	closureLawInvariant_iff_no_orbit_gap Paper4dFrontier/ AdmissibleCharacterization.lean	FR204	no_exact_closureLawInvariant_classifier_iff_exists_orbit_gap Paper4dFrontier/ AdmissibleCharacterization.lean
FR206	actionCount_profileCompressedSlice Paper4dFrontier/DistinctActionProfiles.lean	FR207	decisionEquiv_profileCompressedSlice_iff Paper4dFrontier/DistinctActionProfiles.lean
FR208	profileCompressedSlice_preserves_exactCertification Paper4dFrontier/DistinctActionProfiles.lean	FR209	profileCompressedSlice_bounded_actions Paper4dFrontier/DistinctActionProfiles.lean
FR210	OrbitGapOn Paper4dFrontier/ AdmissibleCharacterization.lean	FR211	no_orbitGapOn_of_exact_classifiable_by_closureLawInvariant_onDomain Paper4dFrontier/ AdmissibleCharacterization.lean
FR212	exact_classifiable_by_closureLawInvariant_onDomain_iff_no_orbitGapOn Paper4dFrontier/ AdmissibleCharacterization.lean	FR213	no_exact_closureLawInvariant_classifier_onDomain_iff_orbitGapOn Paper4dFrontier/ AdmissibleCharacterization.lean
FR214	boundedPatternScheme_holds_largeActionCount_iff Paper4dFrontier/ AdmissibleCharacterization.lean	FR215	boundedPatternDefinable_eventually_constant_in_actionCount Paper4dFrontier/ AdmissibleCharacterization.lean
FR216	boundedPatternDefinable_largeActionCount_agrees Paper4dFrontier/ AdmissibleCharacterization.lean	FR217	payloadSufficient_iff_realizingProblem_isSufficient Paper4dFrontier/Realizability.lean
FR218	payloadRelevant_iff_realizingProblem_isRelevant Paper4dFrontier/Realizability.lean	FR219	payloadIrrelevant_iff_realizingProblem_isIrrelevant Paper4dFrontier/Realizability.lean
FR220	payloadMinimalSufficient_iff_realizingProblem_isMinimalSufficient Paper4dFrontier/Realizability.lean	FR221	payloadSufficientSets_eq_realizingProblem_sufficientSets Paper4dFrontier/Realizability.lean
FR222	payloadRelevantSet_eq_realizingProblem_relevantSet Paper4dFrontier/Realizability.lean	FR223	feasiblePayloadSufficient_iff_lawDecisionProblem_isSufficient Paper4dFrontier/Realizability.lean

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ID	Lean Handle / Source	ID	Lean Handle / Source
FR224	feasiblePayloadRelevant_iff_lawDecision Problem_isRelevant Paper4dFrontier/Realizability.lean	FR225	feasiblePayloadIrrelevant_iff_lawDecision Problem_isIrrelevant Paper4dFrontier/Realizability.lean
FR226	setValuedPayloadSufficient_iff_totalizedLaw DecisionProblem_isSufficient Paper4dFrontier/Realizability.lean	FR227	setValuedPayloadRelevant_iff_totalizedLaw DecisionProblem_isRelevant Paper4dFrontier/Realizability.lean
FR228	setValuedPayloadIrrelevant_iff_totalizedLaw DecisionProblem_isIrrelevant Paper4dFrontier/Realizability.lean	FR229	outputSemanticsSufficient_iff_totalizedLaw DecisionProblem_isSufficient Paper4dFrontier/Realizability.lean
FR230	outputSemanticsRelevant_iff_totalizedLaw DecisionProblem_isRelevant Paper4dFrontier/Realizability.lean	FR231	outputSemanticsIrrelevant_iff_totalizedLaw DecisionProblem_isIrrelevant Paper4dFrontier/Realizability.lean
FR232	approximationSemanticsSufficient_iff_ totalizedLawDecisionProblem_isSufficient Paper4dFrontier/Realizability.lean	FR233	approximationSemanticsRelevant_iff_ totalizedLawDecisionProblem_isRelevant Paper4dFrontier/Realizability.lean
FR234	approximationSemanticsIrrelevant_iff_ totalizedLawDecisionProblem_isIrrelevant Paper4dFrontier/Realizability.lean	FR235	outputSemanticsSufficientSets_eq_of_output SemanticsEquivalent Paper4dFrontier/Realizability.lean
FR236	outputSemanticsRelevantSet_eq_of_output SemanticsEquivalent Paper4dFrontier/Realizability.lean	FR237	quotientMap_realizes_setoid_asOutput Semantics Paper4dFrontier/Realizability.lean
FR240	exists_outputSemantics_realizing_setoid Paper4dFrontier/Realizability.lean	FR241	outputSemanticsSetoid Paper4dFrontier/Realizability.lean
FR242	SemanticallyExtensionalMap Paper4dFrontier/Realizability.lean	FR243	semanticallyExtensionalMap_factors_through_ outputSemanticsQuotient Paper4dFrontier/Realizability.lean
FR244	semanticallyExtensionalClaim_factors_ through_outputSemanticsQuotient Paper4dFrontier/Realizability.lean	FR245	optimizerComputation_polytime_closureLaw Invariant Paper4dFrontier/ ComputeCostApplications.lean
FR246	optimizerSetPayload_polytime_closureLaw Invariant Paper4dFrontier/ ComputeCostApplications.lean	FR247	optimizerSetSearch_polytime_closureLaw Invariant Paper4dFrontier/ ComputeCostApplications.lean
FR248	optimizerComputation_polytime_classifier_ agrees_on_closureEquivalent_of_correctOn Domain Paper4dFrontier/ ComputeCostApplications.lean	FR249	optimizerComputation_polytime_classifier_ agrees_on_closureEquivalent Paper4dFrontier/ ComputeCostApplications.lean
FR250	no_correct_optimizerComputation_polytime_ classifier_decides_dominantPair Paper4dFrontier/ ComputeCostApplications.lean	FR251	no_admissibleNormalizationPredicate_ optimizerComputation_polytime_and_dominant Pair Paper4dFrontier/ ComputeCostApplications.lean
FR252	CorrectnessForcesOrbitAgreementOnDomain Paper4dFrontier/ AdmissibleCharacterization.lean	FR253	no_orbitGapOn_of_correct_classifier_on Domain_of_forcedOrbitAgreement Paper4dFrontier/ AdmissibleCharacterization.lean
FR254	correct_classifier_onDomain_iff_no_orbitGap On_of_forcedOrbitAgreement Paper4dFrontier/ AdmissibleCharacterization.lean	FR255	no_correct_classifier_onDomain_iff_orbitGap On_of_forcedOrbitAgreement Paper4dFrontier/ AdmissibleCharacterization.lean

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ID	Lean Handle / Source	ID	Lean Handle / Source
FR256	optimizerComputation_polytime_correct_classifier_onDomain_iff_no_orbitGapOn Paper4dFrontier/ ComputeCostApplications.lean	FR259	optimizerSetPayload_polytime_classifier_agrees_on_closureEquivalent_of_correctOnDomain Paper4dFrontier/ ComputeCostApplications.lean
FR260	optimizerSetPayload_polytime_classifier_agrees_on_closureEquivalent Paper4dFrontier/ ComputeCostApplications.lean	FR261	optimizerSetSearch_polytime_classifier_agrees_on_closureEquivalent_of_correctOnDomain Paper4dFrontier/ ComputeCostApplications.lean
FR262	optimizerSetSearch_polytime_classifier_agrees_on_closureEquivalent Paper4dFrontier/ ComputeCostApplications.lean	FR263	relevant_of_uniformApprox_of_strict_gap_witness Paper4dFrontier/ ApproximateAdmissibility.lean
FR264	relevance_can_flip_under_arbitrarily_small_uniform_perturbation Paper4dFrontier/ ApproximateAdmissibility.lean	FR266	not_sufficient_of_uniformApprox_of_strict_gap_witness Paper4dFrontier/ ApproximateAdmissibility.lean
FR267	sufficiency_can_flip_under_arbitrarily_small_uniform_perturbation Paper4dFrontier/ ApproximateAdmissibility.lean	FR268	pacGuaranteeSemanticsSufficient_iff_totalizedLawDecisionProblem_isSufficient Paper4dFrontier/Realizability.lean
FR269	pacGuaranteeSemanticsRelevant_iff_totalizedLawDecisionProblem_isRelevant Paper4dFrontier/Realizability.lean	FR270	pacGuaranteeSemanticsIrrelevant_iff_totalizedLawDecisionProblem_isIrrelevant Paper4dFrontier/Realizability.lean
FR271	regretGuaranteeSemanticsSufficient_iff_totalizedLawDecisionProblem_isSufficient Paper4dFrontier/Realizability.lean	FR272	regretGuaranteeSemanticsRelevant_iff_totalizedLawDecisionProblem_isRelevant Paper4dFrontier/Realizability.lean
FR273	regretGuaranteeSemanticsIrrelevant_iff_totalizedLawDecisionProblem_isIrrelevant Paper4dFrontier/Realizability.lean	FR274	statisticalRiskSemanticsSufficient_iff_totalizedLawDecisionProblem_isSufficient Paper4dFrontier/Realizability.lean
FR275	statisticalRiskSemanticsRelevant_iff_totalizedLawDecisionProblem_isRelevant Paper4dFrontier/Realizability.lean	FR276	statisticalRiskSemanticsIrrelevant_iff_totalizedLawDecisionProblem_isIrrelevant Paper4dFrontier/Realizability.lean
FR277	anytimeGuaranteeSemanticsSufficient_iff_totalizedLawDecisionProblem_isSufficient Paper4dFrontier/Realizability.lean	FR278	anytimeGuaranteeSemanticsRelevant_iff_totalizedLawDecisionProblem_isRelevant Paper4dFrontier/Realizability.lean
FR279	anytimeGuaranteeSemanticsIrrelevant_iff_totalizedLawDecisionProblem_isIrrelevant Paper4dFrontier/Realizability.lean	FR280	finiteHorizonGuaranteeSemanticsSufficient_iff_totalizedLawDecisionProblem_isSufficient Paper4dFrontier/Realizability.lean
FR281	finiteHorizonGuaranteeSemanticsRelevant_iff_totalizedLawDecisionProblem_isRelevant Paper4dFrontier/Realizability.lean	FR282	finiteHorizonGuaranteeSemanticsIrrelevant_iff_totalizedLawDecisionProblem_isIrrelevant Paper4dFrontier/Realizability.lean
FR283	statisticalGuaranteeSemanticsSufficient_Sets_eq_of_outputSemanticsEquivalent Paper4dFrontier/Realizability.lean	FR284	statisticalGuaranteeSemanticsRelevantSet_eq_of_outputSemanticsEquivalent Paper4dFrontier/Realizability.lean
FR285	statisticalGuarantee_classifier_agrees_on_closureEquivalent_of_correctOnDomain_of_transfer Paper4dFrontier/ StatisticalSemanticsApplications.lean	FR286	no_correctOnDomain_statisticalGuarantee_classifier_of_orbit_gap_of_transfer Paper4dFrontier/ StatisticalSemanticsApplications.lean

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ID	Lean Handle / Source	ID	Lean Handle / Source
FR287	statisticalGuarantee_correct_classifier_on Domain_iff_no_orbitGapOn_of_transfer Paper4dFrontier/ StatisticalSemanticsApplications.lean	FR288	opt_eq_of_uniformApprox_of_uniformStrictGap Cover Paper4dFrontier/ ApproximateAdmissibility.lean
FR289	sufficientSets_eq_of_uniformApprox_of_ uniformStrictGapCover Paper4dFrontier/ ApproximateAdmissibility.lean	FR290	relevantSet_eq_of_uniformApprox_of_uniform StrictGapCover Paper4dFrontier/ ApproximateAdmissibility.lean
FR291	randomizedGuaranteeSemanticsSufficient_iff_ totalizedLawDecisionProblem_isSufficient Paper4dFrontier/Realizability.lean	FR292	randomizedGuaranteeSemanticsRelevant_iff_ totalizedLawDecisionProblem_isRelevant Paper4dFrontier/Realizability.lean
FR293	randomizedGuaranteeSemanticsIrrelevant_iff_ totalizedLawDecisionProblem_isIrrelevant Paper4dFrontier/Realizability.lean	FR294	randomizedGuarantee_classifier_agrees_on_ closureEquivalent_of_correctOnDomain_of_ transfer Paper4dFrontier/ StatisticalSemanticsApplications.lean
FR295	no_correctOnDomain_randomizedGuarantee_ classifier_of_orbit_gap_of_transfer Paper4dFrontier/ StatisticalSemanticsApplications.lean	FR296	randomizedGuarantee_correct_classifier_on Domain_iff_no_orbitGapOn_of_transfer Paper4dFrontier/ StatisticalSemanticsApplications.lean
FR297	transferredSemantics_classifier_agrees_on_ closureEquivalent_of_correctOnDomain Paper4dFrontier/ StatisticalSemanticsApplications.lean	FR298	no_correctOnDomain_transferredSemantics_ classifier_of_orbit_gap Paper4dFrontier/ StatisticalSemanticsApplications.lean
FR299	transferredSemantics_correct_classifier_on Domain_iff_no_orbitGapOn Paper4dFrontier/ StatisticalSemanticsApplications.lean	FR300	decisionEquiv_iff_of_uniformApprox_of_ uniformStrictGapCover Paper4dFrontier/ ApproximateAdmissibility.lean
FR301	isMinimalSufficient_iff_of_uniformApprox_ of_uniformStrictGapCover Paper4dFrontier/ ApproximateAdmissibility.lean	FR302	outputSemanticsExactRelevanceProfile_eq_of_ outputSemanticsEquivalent Paper4dFrontier/Realizability.lean
FR303	outputSemanticsExactRelevanceProfile_eq_ totalizedLawDecisionProblem Paper4dFrontier/Realizability.lean	FR304	agreeOn_univ_iff_eq_of_finiteIndicator CoordinateSpace Paper4dFrontier/Realizability.lean
FR305	finite_outputSemantics_allCoordinates Sufficient Paper4dFrontier/Realizability.lean	FR306	finite_outputSemantics_realized_by_exact Certification Paper4dFrontier/Realizability.lean
FR307	agreeOn_univ_iff_eq_of_singletonIdentity CoordinateSpace Paper4dFrontier/Realizability.lean	FR308	outputSemantics_admits_coordinate Presentation Paper4dFrontier/Realizability.lean
FR311	encodable_stateSpace_admits_countable BooleanPresentation Paper4dFrontier/Realizability.lean	FR312	encodable_discreteMeasurable_stateSpace_ admits_measurable_countableBoolean Presentation Paper4dFrontier/Realizability.lean
FR313	encodable_discreteTopological_stateSpace_ admits_continuous_countableBoolean Presentation Paper4dFrontier/Realizability.lean	FR314	agreeOn_univ_iff_eq_of_finiteBinary CoordinateSpace Paper4dFrontier/Realizability.lean
FR315	finite_exactSpecification_admits_lowDim BooleanPresentation Paper4dFrontier/Realizability.lean	FR316	IdentityOutputClosureSpec_classifier_ agrees_on_closureEquivalent_of_correctOn Domain Paper4dFrontier/ ComputeCostExternalOutputs.lean

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ID	Lean Handle / Source	ID	Lean Handle / Source
FR317	IdentityOutputClosureSpec.no_correctOnDomain_classifier_of_orbit_gap Paper4dFrontier/ ComputeCostExternalOutputs.lean	FR318	hypothesisOutput_classifier_agrees_on_closureEquivalent_of_correctOnDomain Paper4dFrontier/ ComputeCostExternalOutputs.lean
FR319	estimatorOutput_classifier_agrees_on_closureEquivalent_of_correctOnDomain Paper4dFrontier/ ComputeCostExternalOutputs.lean	FR320	policyOutput_classifier_agrees_on_closureEquivalent_of_correctOnDomain Paper4dFrontier/ ComputeCostExternalOutputs.lean
FR321	randomizedProcedure_classifier_agrees_on_closureEquivalent_of_correctOnDomain Paper4dFrontier/ ComputeCostExternalOutputs.lean	FR322	no_correctOnDomain_hypothesisOutput_classifier_of_orbit_gap Paper4dFrontier/ ComputeCostExternalOutputs.lean
FR323	no_correctOnDomain_estimatorOutput_classifier_of_orbit_gap Paper4dFrontier/ ComputeCostExternalOutputs.lean	FR324	no_correctOnDomain_policyOutput_classifier_of_orbit_gap Paper4dFrontier/ ComputeCostExternalOutputs.lean
FR325	no_correctOnDomain_randomizedProcedure_classifier_of_orbit_gap Paper4dFrontier/ ComputeCostExternalOutputs.lean	FR326	TransportedOutputClosureSpec.classifier_agrees_on_closureEquivalent_of_correctOnDomain Paper4dFrontier/ ComputeCostExternalOutputs.lean
FR327	TransportedOutputClosureSpec.no_correctOnDomain_classifier_of_orbit_gap Paper4dFrontier/ ComputeCostExternalOutputs.lean	FR328	IdentityOutputClosureSpec.correctOnDomain_iff_correctOnDomain_transport Paper4dFrontier/ ComputeCostExternalOutputs.lean
FR329	representationRelativeHypothesis_classifier_agrees_on_closureEquivalent_of_correctOnDomain Paper4dFrontier/ ComputeCostExternalOutputs.lean	FR330	representationRelativeEstimator_classifier_agrees_on_closureEquivalent_of_correctOnDomain Paper4dFrontier/ ComputeCostExternalOutputs.lean
FR331	representationRelativePolicy_classifier_agrees_on_closureEquivalent_of_correctOnDomain Paper4dFrontier/ ComputeCostExternalOutputs.lean	FR332	representationRelativeRandomizedProcedure_classifier_agrees_on_closureEquivalent_of_correctOnDomain Paper4dFrontier/ ComputeCostExternalOutputs.lean
FR333	no_correctOnDomain_representationRelativeHypothesis_classifier_of_orbit_gap Paper4dFrontier/ ComputeCostExternalOutputs.lean	FR334	no_correctOnDomain_representationRelativeEstimator_classifier_of_orbit_gap Paper4dFrontier/ ComputeCostExternalOutputs.lean
FR335	no_correctOnDomain_representationRelativePolicy_classifier_of_orbit_gap Paper4dFrontier/ ComputeCostExternalOutputs.lean	FR336	no_correctOnDomain_representationRelativeRandomizedProcedure_classifier_of_orbit_gap Paper4dFrontier/ ComputeCostExternalOutputs.lean
FR340	booleanPayloadTransfer Paper4dFrontier/Realizability.lean	FR341	predicateTransfer Paper4dFrontier/Realizability.lean
FR342	sufficiency_is_relation_refinement Paper4dFrontier/Realizability.lean	FR343	relevance_is_erased_failure_of_refinement Paper4dFrontier/Realizability.lean
FR345	exactSemanticsQuotient_universal_characterization Paper4dFrontier/Realizability.lean	FR346	exactnessMeansExactAgreementWithValidity Paper4dFrontier/Realizability.lean
FR347	closure_sound_package_no_go_uses_only_closureLawInvariant Paper4dFrontier/ FullBinaryPairwiseDomain.lean	FR348	fullBinaryPairwiseDomain_closure_closed Paper4dFrontier/ FullBinaryPairwiseDomain.lean

(continued...)

ID	Lean Handle / Source	ID	Lean Handle / Source
FR349	fullBinaryPairwiseDomain_contains_four_obstruction_families Paper4dFrontier/ FullBinaryPairwiseDomain.lean	FR350	no_correct_tractability_classifier_on_full_BinaryPairwiseDomain Paper4dFrontier/ FullBinaryPairwiseDomain.lean
FR351	ExactCorrectnessSpecification.universal_scope_over_rigorously_specified_problems Paper4dFrontier/Realizability.lean	FR352	DecisionQuotient.DecisionProblem.minimal_Sufficient_eq_relevant' paper4/DecisionQuotient/Sufficiency.lean
FR353	DecisionQuotient.DecisionProblem.sufficient_Sets_principal' paper4/DecisionQuotient/Sufficiency.lean	FR354	DecisionQuotient.srank_le_sufficient_card paper4/DecisionQuotient/Tractability/ StructuralRank.lean
FR355	closureLawInvariant_iff_closureHull_eq_self Paper4dFrontier/ AdmissibleCharacterization.lean	FR356	no_orbitGapOn_iff_closureHull_disjoint Paper4dFrontier/ AdmissibleCharacterization.lean
FR357	exact_classifiable_by_closureLawInvariant_onDomain_iff_closureHull_disjoint Paper4dFrontier/ AdmissibleCharacterization.lean	FR358	closureHull_least_exact_classifier_on_Domain_of_no_orbitGapOn Paper4dFrontier/ AdmissibleCharacterization.lean
FR359	binary_pairwise_symmetry_decisionRelevant_Graph_dichotomy Paper4dFrontier/ DecisionRelevantPairwiseDichotomy.lean	FR361	no_optimizerSetSearch_exactSpecification_characterization_on_fullBinaryPairwise_Domain Paper4dFrontier/ExactSpecificationNoGo.lean
FR362	closureLawInvariant_iff_of_closure_Equivalent Paper4dFrontier/ AdmissibleCharacterization.lean		

2 Claim-to-Lean Handle Mapping

This section maps each paper claim to its corresponding Lean formalization.

Paper claim	Lean handle
Corollary 2.49: Exact Approximation Semantics Transfer	FR232, FR233, FR234
Corollary 2.29: Boolean Payload Transfer	FR340
Corollary 2.9: Constant-Optimizer Collapse Forces Trivial Certification	FR52, FR53
Corollary 4.25: Domain Restriction Helps Only by Removing Orbit Gaps	FR252, FR253, FR254, FR255, FR256
Corollary 2.55: Every State Equivalence Relation Is Realizable as Exact Output Semantics	FR237, FR240
Corollary 2.23: Compute-Cost Version: External Output Objects	FR316, FR317, FR318, FR319, FR320, FR321, FR322, FR323, FR324, FR325, FR326, FR327, FR328
Corollary 4.18: No Finite Structural Tractability Proxy on the Full Binary Pairwise Domain	FR350
Corollary 4.24: Least Exact Closure-Invariant Classifier	FR358
Corollary 4.16: No Finite Structural Tractability Proxy for the Obstruction Targets	FR193, FR197, FR198, FR199
Corollary 4.21: Orbit-Gap Completeness on Closure-Closed Domains	FR210, FR211, FR212, FR213
Corollary 2.22: Compute-Cost Version: Canonical Payload and Search Tasks	FR259, FR260, FR261, FR262
Corollary 2.30: Predicate Transfer	FR341

Paper claim	Lean handle
Corollary 2.47: Randomized-Output Guarantee Semantics Inherit the Closure-Orbit Consequences	FR291, FR292, FR293, FR294, FR295, FR296
Corollary 2.46: Randomized-Output Guarantee Semantics Transfer	FR291, FR292, FR293
Corollary 2.33: Arbitrary Exact Output Semantics Transfer	FR229, FR230, FR231
Corollary 2.3: Relevance Is Failure of Erased Sufficiency	FR49, FR50
Corollary 2.37: Admissible-Output Relevance Is Failure of Erased Sufficiency	FR343
Corollary 2.31: Nonempty Set-Valued Payload Transfer	FR223, FR224, FR225
Corollary 2.51: Arbitrarily Small Uniform Perturbations Can Flip Relevance	FR264
Corollary 2.52: Arbitrarily Small Uniform Perturbations Can Flip Sufficiency	FR267
Corollary 2.7: Structural Rank Lower-Bounds Any Sufficient Description	FR354
Corollary 2.48: Statistical Guarantee Semantics Inherit the Closure-Orbit Consequences	FR268, FR269, FR270, FR271, FR272, FR273, FR274, FR275, FR276, FR277, FR278, FR279, FR280, FR281, FR282, FR283, FR284, FR285, FR286, FR287, FR288, FR289, FR290, FR291, FR292, FR293, FR294, FR295, FR296, FR297, FR298, FR299
Corollary 2.45: Statistical Guarantee Semantics Transfer	FR268, FR269, FR270, FR271, FR272, FR273, FR274, FR275, FR276, FR277, FR278, FR279, FR280, FR281, FR282
Corollary 2.4: Certification Statistics Factor Through the Quotient Relation	FR41, FR42, FR43, FR44
Corollary 2.2: Sufficiency Is Relation Refinement	FR48
Corollary 2.6: Sufficient Sets Form a Principal Filter	FR353
Corollary 2.32: Arbitrary Set-Valued Payload Transfer via Failure Tokens	FR226, FR227, FR228
Corollary 2.24: Compute-Cost Version: Representation-Relative Output Objects	FR326, FR327, FR328, FR329, FR330, FR331, FR332, FR333, FR334, FR335, FR336
Corollary 4.19: No Universal Exact-Certification Characterization Escapes the Binary Pairwise Obstruction	FR351, FR361
Corollary 2.39: Universal Scope Over Rigorously Specified Problems	FR351
Lemma 4.6: Primitive-Law Invariance Equals Orbit Invariance	FR362
Proposition 2.25: The Finite Structural Class Is Nonempty	FR200
Proposition 2.11: Positive Affine Utility Reparameterizations Are Invisible	FR13, FR14, FR15, FR16
Proposition 2.50: Approximate Relevance and Sufficiency Claims Need Explicit Stability Control	FR263, FR266
Proposition 4.2: Binary Pairwise Symmetry Dichotomy	FR118, FR119, FR120
Proposition 2.27: Bounded-Pattern Predicates Stabilize Above a Finite Action Bound	FR214, FR215, FR216
Proposition 2.40: Canonical Exact Relevance Profile	FR302, FR303
Proposition 2.18: Closure Operations Preserve Exact Certification	FR15, FR16, FR17, FR18, FR19, FR20, FR55, FR56, FR57, FR58, FR59, FR60, FR83, FR84, FR85
Proposition 4.22: Closure-Invariant Predicates Are Exactly the Fixed Points of Orbit Saturation	FR355

Paper claim	Lean handle
Proposition 2.43: Countable Exact Specifications Admit Countable Boolean Presentations	FR311, FR312, FR313
Proposition 4.3: Decision-Relevant Binary Pairwise Dichotomy	FR121, FR122, FR123, FR124
Proposition 2.1: Exact Certification Depends Only on the Decision Quotient Relation	FR30, FR31, FR32, FR33, FR34, FR35, FR37, FR51
Proposition 2.26: Bounded Distinct Action Profiles Compress to Bounded Actions	FR206, FR207, FR208, FR209
Proposition 2.12: Duplicate Actions and Duplicate States Preserve Certification	FR54, FR55, FR56, FR68, FR69, FR70, FR71, FR72, FR73
Proposition 2.10: Explicit Enumeration Is Parameter-Dependent, Not Structural	FR66, FR67
Proposition 2.41: Every Exact Specification Admits a Coordinate Presentation	FR307, FR308
Proposition 2.34: Exactness Means Exact Agreement With Validity	FR346
Proposition 2.42: Finite Exact Specifications Admit Coordinate Presentations	FR304, FR305, FR306
Proposition 2.44: Finite Exact Specifications Admit Low-Dimensional Boolean Presentations	FR314, FR315
Proposition 4.17: Full Binary Pairwise Domain Is Closure-Closed	FR348, FR349
Proposition 2.53: Global Approximation Stability Under Uniform Strict Gaps	FR288, FR289, FR290, FR291, FR292, FR293, FR294, FR295, FR296, FR297, FR298, FR299, FR300, FR301
Proposition 2.15: Invariance Alone Is Too Weak	FR21, FR22, FR23
Remark 4.15: Logical Dependency of the No-Go	FR347
Proposition 2.5: Minimal Sufficient Sets Are Canonical on Product Spaces	FR352
Proposition 2.17: Unrestricted Predicates Trivialize Exact Characterization	FR145
Proposition 4.20: Orbit-Gap Completeness for Exact Classification	FR201, FR202, FR203, FR204
Proposition 4.7: Orbit-Gap Template	FR185
Proposition 2.28: Deterministic Payload Transfer	FR217, FR218, FR219, FR220, FR221, FR222
Proposition 2.14: Quotient Size Is Unbounded Under Realizability	FR24, FR38
Proposition 2.13: Relabeling Invariance Is Forced by Exact Certification	FR17, FR18, FR19, FR20
Proposition 2.54: Exact Semantic Claims Depend Only on Admissible-Output Equivalence	FR235, FR236
Proposition 2.56: Semantically Extensional Claims Factor Through the Exact-Semantics Quotient	FR241, FR242, FR243, FR244
Proposition 2.16: Independent Summary Frameworks Converge on the Same Structural Core	FR178, FR179, FR180, FR181, FR182
Proposition 2.36: Admissible-Output Sufficiency Is Relation Refinement	FR342
Proposition 4.4: Symmetric Binary Pairwise Decision-Relevant Graphs Are Either Empty or Complete	FR359
Proposition 2.8: Zero-Distortion Summaries Refine the Optimizer Quotient	FR176, FR177
Theorem 4.14: Closure-Sound Package No-Go	FR193
Theorem 2.20: Tractability Classifiers Are Forced to Be Closure-Invariant	FR197, FR198, FR199, FR245, FR246, FR247, FR248, FR249
Theorem 4.10: Dominant-Pair Finite-Structural No-Go	FR186

Paper claim	Lean handle
Theorem 4.23: Exact Classification Equals Hull Separation	FR356, FR357
Theorem 2.38: Exact Semantics Quotient Universality	FR345
Theorem 4.12: Ghost-Action Finite-Structural No-Go	FR188
Theorem 3.1: Every Labeling Kernel Is Optimizer-Realizable	FR7, FR8
Theorem 4.11: Margin-Masking Finite-Structural No-Go	FR187
Theorem 4.13: Offset Finite-Structural No-Go	FR189
Theorem 2.21: Compute-Cost Version: Optimizer Computation	FR248

Auto summary: mapped 76/76.